

Parasitoid Mark-Release-Recapture Techniques— I. Development of a Battery-operated Suction Trap for Collecting Minute Insects

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We present a detailed description of how to build a lightweight, battery-operated suction trap to selectively collect minute insects. A single researcher can collect the contents from dozens of these traps in a matter of minutes. The trap is inexpensive, user-friendly, portable and non-lethal and non-destructive to trapped insects.

Keywords: *insect trap, mark-release-recapture, sampling, dispersal, parasitoid*

INTRODUCTION

A thorough understanding of parasitoid dispersal patterns is required to effectively utilize parasitoids for biological pest control. Parasitoids released in augmentative biological control programs must spread from the release site to occupy the targeted area. However, quantifying parasitoid dispersal is difficult. Generally, parasitoid dispersal has been researched by using mark-release-recapture (MRR) techniques (Southwood, 1978). MRR involves mass-marking insects with a material (e.g. dusts, trace elements, proteins etc.), releasing them into the field, and recapturing them at given time and distance intervals after their dispersal. A major barrier to tracking parasitoid movement effectively in the field is the lack of reliable methods to recapture marked parasitoids.

Researchers have used a wide variety of techniques to recapture marked parasitoids (McEwen, 1997). Sticky traps are probably the most commonly used traps (excluding sweep nets) for trapping small and delicate parasitoids because they are inexpensive and easy to use. Typically, parasitoids are released into the center of an experimental area that contains a grid-like arrangement of sticky cards (Hendricks, 1967; Fernandes *et al.*,

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1997; many others). The sticky cards are examined for the presence of the released parasitoids to determine how far and how fast they traveled. Additionally, numerous sticky traps can be quickly and strategically placed and replaced in the field, which facilitates continuous monitoring of parasitoid populations over a large area (Neuenschwander, 1982; Antolin & Strong, 1987; Udayagiri *et al.*, 1997; Romeis *et al.*, 1999; Williams & Martinson, 2000; many others). However, sticky traps are sometimes not practical for MRR studies. The stickiness of the trap can destroy the integrity of delicate parasitoids, making it difficult to examine the captured insects for markers. This is especially true if the captured insects must be removed from the trap and chemically analyzed for the presence of the marker (Akey *et al.*, 1991; Hagler & Jackson, 2001). Non-sticky insect traps were developed for capturing certain small insects (e.g. McPhail traps and Malaise traps) (McEwen, 1997; Platt *et al.*, 1999). For example, a modified McPhail trap was developed specifically for capturing adult whiteflies (Chu & Henneberry, 1998). However, this trap is not useful for many studies because it does not capture whitefly parasitoids (Chu & Henneberry, 1998; Hoelmer *et al.*, 1998).

Sweep nets and various engine-driven vacuum or suction traps have also been used to collect insects (Dietrick, 1961; Stern *et al.*, 1965; Ellington *et al.*, 1984; Beerwinkle & Coppedge, 1998). In most cases sweep nets and engine-driven vacuum traps are not very practical for collecting and counting tiny parasitoids because they non-selectively collect an enormous amount of non-target insects and plant debris. As a consequence the samples must then be tediously sorted through. Furthermore, small and delicate parasitoids can be destroyed or lost in sweep net or vacuum samples (McEwen, 1997). Another major pitfall associated with sweep nets and engine vacuums is that they are not practical for simultaneously collecting insects for MRR studies that require temporal or spatial sampling schemes.

The drawbacks of the trapping devices described above were the impetus for the development of the trap described in this paper. For our studies of parasitoid dispersal we needed a user-friendly, inexpensive, lightweight, durable, and non-destructive trap that selectively collects minute insects. Here we provide a step-by-step guide to building such a trap. This is the first paper of a two part series describing novel MRR techniques. In the companion paper also published in this issue (Hagler *et al.*, 2002) we describe a protein marking technique that is useful for labeling tiny parasitoids. In the second paper we use the fan traps described herein and the protein marking technique to study the dispersal characteristics of the whitefly parasitoid, *Eretmocerus emiratus* Zolnerowich & Rose.

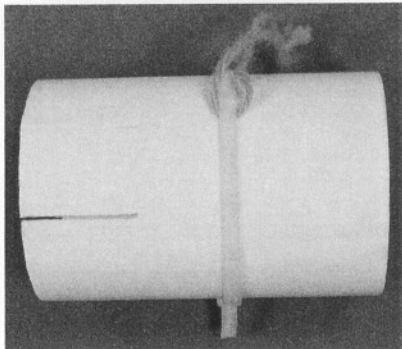
MATERIALS AND METHODS

The supplies needed and the step-by-step instructions for constructing the trap are given in Figure 1. We estimate that the materials needed to build a single trap cost US\$10, excluding labor and batteries. Two D-cell alkaline batteries are required to operate the trap. The 3 V DC motor (Mabuchi Motor, Model 'Arise 260', Hong Kong, China) used to propel the trap was purchased at a hobby shop. All of the other materials required to assemble the trap are readily available at electronic and hardware stores.

The motor and fan blade are housed inside a 6.0 cm outer diameter PVC pipe (Figure 1). A 5.2 cm outer diameter (just slightly smaller than the inner diameter of the PVC pipe) plastic 40 dram snap vial (Thorton Plastic, Salt Lake City, UT, USA) fits snugly into the PVC pipe. It is critical that the collection vial fits snugly into the PVC pipe to avoid vibrating out of the trap and to ensure that the air is drawn through the collection vial and not around it.

The compact and lightweight trap can be mounted almost anywhere in a field with a suitable support such as a tree branch or a wooden pole. For our studies we cut 2.1 cm outer diameter PVC pipe into 1.8 m sections for trap support. We then cut small notches in

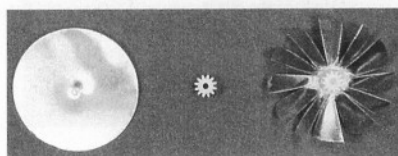
Trap Body;



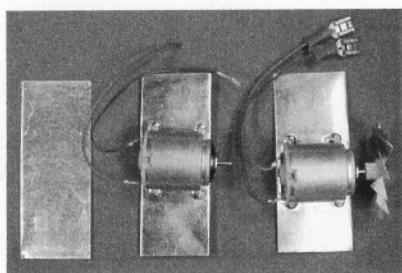
1. Cut PVC pipe (6.0-cm outer diameter) into 13.0-cm sections.
2. Cut a 3.0-cm notch in the lower third of each PVC section with a bandsaw or hacksaw.
3. Make a loop of yarn that is long enough to hang the fan trap onto the PVC pipes described below.
4. Use a zip-tie to attach the yarn loop to the fan trap.

Fan Blades:

5. Cut 4.0-cm circles of aluminum flashing with a dye punch.
6. Make 10, 1.5-cm cuts with scissors on each circle and twist each cut inward to make fan blade.
7. Glue the fan blade to the plastic gear supplied with the electric motor using an adhesive like Shoo Goo (Crown Pacific Int. Inc., Portland, Oregon).



Motor Mount:

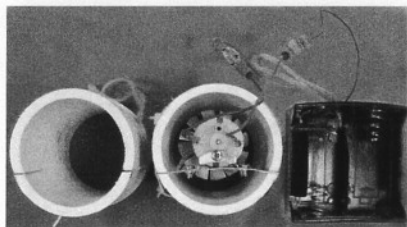


8. Cut a piece of aluminum flashing into a 7.5 x 3.0-cm rectangle.
9. Screw the motor onto the aluminum mount (the screws are supplied with the electric motor).
10. Snap the fan blade onto the motor.
11. Attach terminal connectors to the wires of the electric motor.

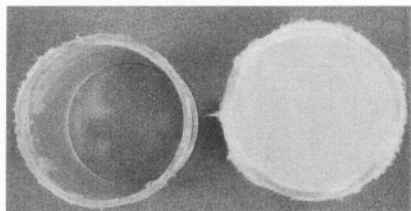
FIGURE 1. The step-by-step instructions and diagrams for constructing a battery-operated suction trap.

Trap Assembly:

12. Insert the mounted motor into the notch in the PVC pipe, bend the overlapping aluminum downward, and wrap duct tape around the external surface of the pipe to hold the motor in place.



Collection Vial:



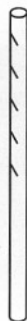
13. Saw off the closed end of a 40-dram plastic snap vial (5.2-cm outer diameter).

14. Cut organdy fabric into 5.6-cm circles and glue the fabric onto the cut end of the vial using hot glue. Trim the overlapping fabric.

Poles:

15. Cut 2.1-cm diameter PVC pipe to the desired length.

16. Cut diagonal notches downward into the PVC pipe to hang the fan and battery pack.



the PVC pipe (Figure 1). The pipe was stuck into the ground and the strings attached to the trap and battery packs were hung from the notches in the pipe. The average wind speed (suction) generated by 30 randomly selected traps was measured with a Turbo-Meter Wind Speed Indicator (Davis Instruments, Hayward, CA, USA).

RESULTS AND DISCUSSION

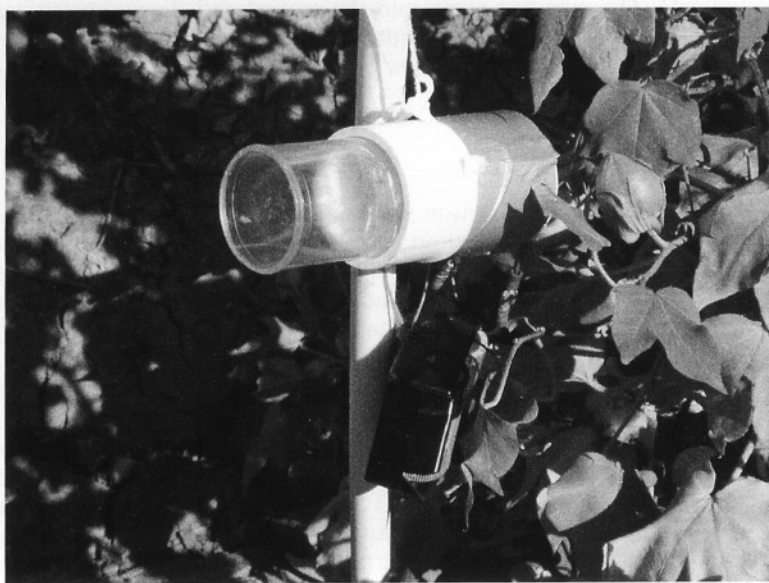
A fully assembled trap mounted near a cotton plant is shown in Figure 2(a). This trap has many practical advantages. First, the collection vial is simple and easy-to-handle. A single person can collect sample vials from dozens of traps in a few minutes because the collection vial from a single trap can be capped, removed, and replaced with another vial in a matter of seconds. Furthermore, the parasitoids trapped in the vial are not killed or destroyed by the trap (Figure 2(b)). This is an advantage over sticky card collections if the trapped insect needs to be identified or analyzed for the presence of a marker. Second, the trap is powerful enough to capture minute insects (e.g. whitefly parasitoids) that fly near its entrance (Figure 2(b)), but it excludes larger insects. The average wind speed generated by a trap was $2.36 (\pm 0.16) \text{ m s}^{-1}$. Third, the interior surface of the collection vial is smooth and prevents captured parasitoids from escaping from the trap. Fourth, two D-cell batteries power a trap for up to 16 h. This feature is useful for MRR studies that require both a temporal and spatial sampling grid. For example, we collected parasitoids from dozens of traps every 2 h over a 32 h period with one battery change (see Hagler *et al.*, 2002). Fifth, the trap is compact and lightweight. A single trap loaded with batteries only weighs $437.4 \pm 4.1 \text{ g}$. This is advantageous when insect collections are needed at many sites within a large experimental area. Finally, the traps are durable. Many of our traps are still running after 100 h of continuous operation under extremely harsh weather conditions.

Although this trap has several advantages over conventional insect traps, it does possess some drawbacks that might limit its usefulness in certain situations. First, it takes $\approx 1 \text{ h}$ to assemble a single trap. However, the time required to build several traps can be decreased if they are assembly line mass-produced. Second, only high quality alkaline batteries, which cost $\approx \text{US\$}0.85$ per battery, provide enough power to continuously operate a trap for 16 h. Rechargeable batteries only provided enough power to run a trap for 2 h (JRH, pers. obs.) and solar power is too expensive. A solar panel costs $\approx \text{US\$}20$ and only provides power in direct sunlight (JEL, pers. obs.). Additionally, the disposal of large quantities of batteries is problematic. Hazardous waste disposal sites do not accept alkaline batteries and it is not advisable to dump large quantities of batteries into local landfills. Local hazardous waste management officials suggest that the safest method to dispose of large quantities of batteries is to place them in small batches of 10 to 20 batteries and discard them over time. Finally, the batteries from each trap must be removed and replaced with fresh ones for studies that require more than 16 h of continuous trap operation. The replacement of batteries is tedious and labor intensive for large-scale experiments (JRH, pers. obs.).

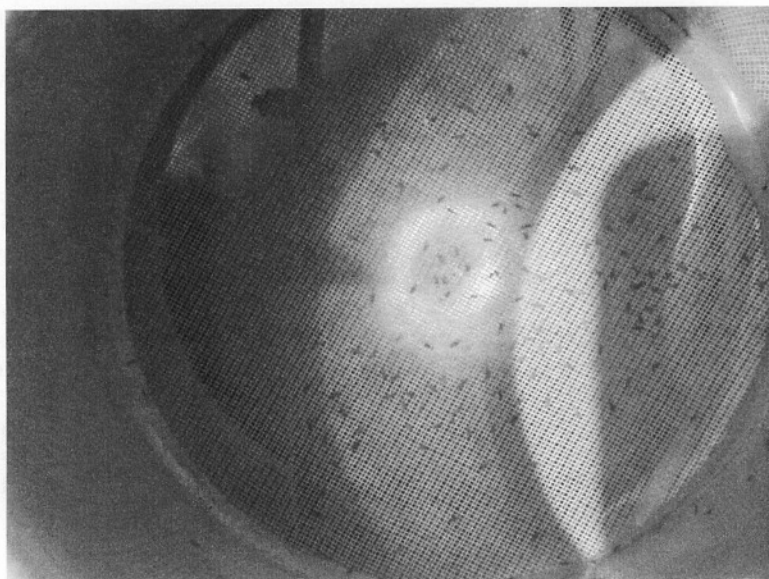
Thus far we have found the trap described herein to be useful for collecting various *Bemisia* (e.g. *Eretmocerus* spp. and *Encarsia* spp.) and *Lygus* parasitoids (e.g. *Anaphes iole*) (see Hagler *et al.*, 2002). We encourage other researchers who use MRR techniques to try this trap for their studies.

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(a)



(b)

1 cm

FIGURE 2. A fully assembled trap mounted on a PVC pipe (a). A trap collection vial containing trapped parasitoids (b).

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